# *Aerosol Type* Constraints Required for Ocean Color Atmospheric Correction


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# Atmospheric Correction Requirements

[Based on: Section 3.2.13. PACE Aerosol Science Objectives – Atmospheric Correction]

- ***SeaWiFS*** Atmospheric Correction approach

  -- Obtain AOD and Aerosol Type from ***Red-NIR*** bands

  -- ***Extrapolate*** to Blue, UV (for next-generation instrument)

  -- ***Correlate*** with surface reflectivity at (MOBY) surface Buoy

## Will this be adequate for the next-generation Ocean Color objectives?

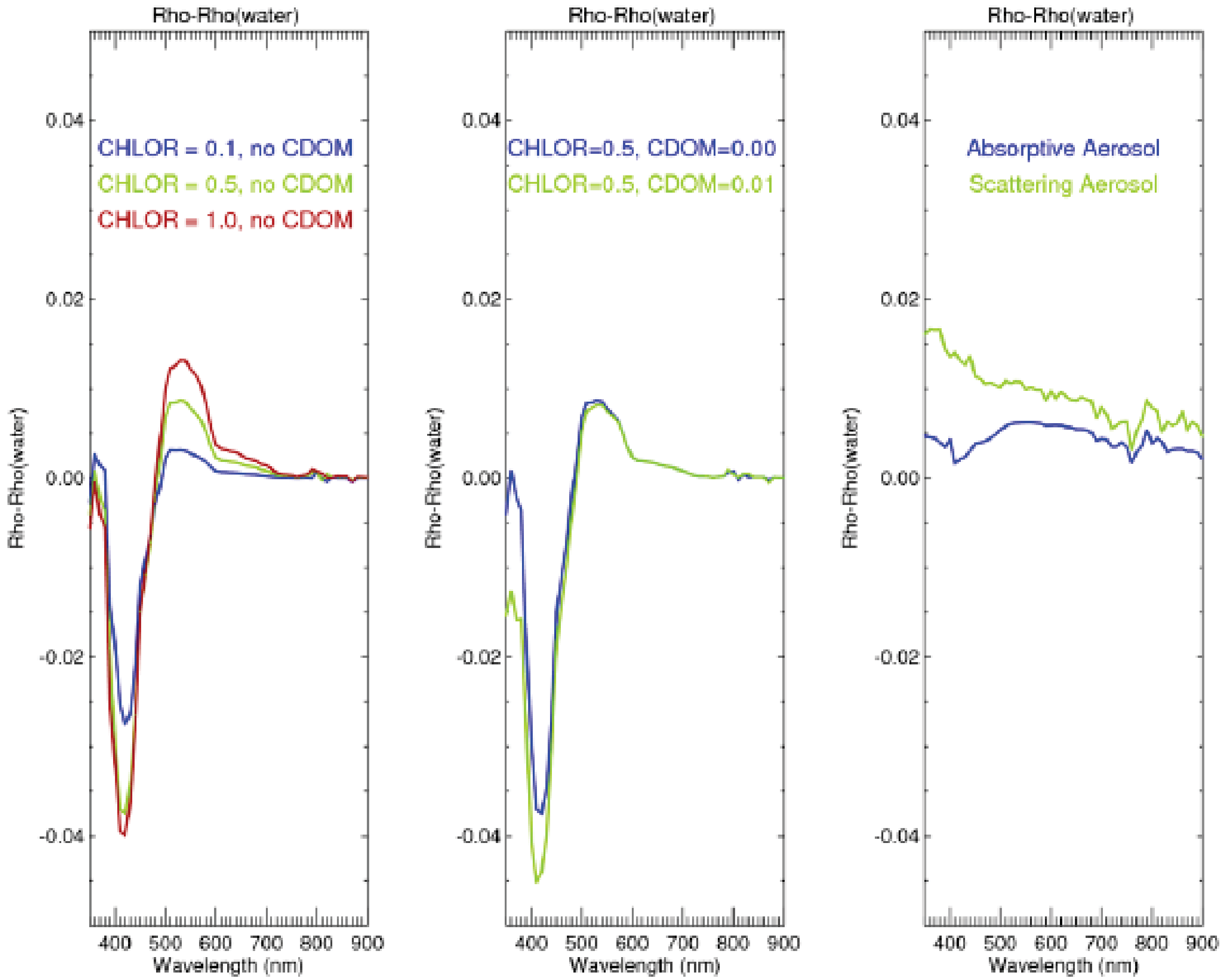
Ocean Color ***parameter sensitivity*** requirements →

Ocean ***surface reflectivity*** sensitivity requirements ($\lambda$) →

TOA ***reflectivity*** sensitivity requirements ($\lambda$, AOD, type) →

Aerosol ***Type, AOD*** sensitivity requirements

# Impact of CDOM, Chlorophyll-a, and Absorbing & Non-absorbing Aerosols On ***TOA Spectral Reflectance***




Chlorophyll-a

CDOM + Chlorophyll-a

Aerosol
$AOD_{500}$ =0.1

*S. Massey, 2013*

# 16,154 *AERONET - SeaWiFS* **Coincidences**

## [49 AERONET Sites]

| Site | Number matches | Climatological Mean (standard deviation) of AERONET AOD 380 nm | 440 nm | 500 nm | 550 nm | SeaWiFS -AERONET Coincidences 675 nm | 870 nm | Site Type | Region | Main Aerosol |
|---|---|---|---|---|---|---|---|---|---|---|
| Crozet Island | 50 | 0.068 (0.043) | 0.061 (0.041) | 0.059 (0.042) | 0.057 (0.040) | 0.049 (0.037) | 0.048 (0.034) | Island | S Indian Ocean | Maritime |
| Rottnest Island | 219 | 0.080 (0.034) | 0.063 (0.031) | 0.062 (0.029) | 0.059 (0.027) | 0.051 (0.026) | 0.044 (0.025) | Coastal Isl. | W Australia | Maritime |
| Reunion St. Denis | 121 | 0.099 (0.045) | 0.077 (0.034) | n/a (n/a) | 0.064 (0.027) | 0.053 (0.022) | 0.046 (0.019) | Island | SW Indian Ocean | Maritime |
| Amsterdam Island | 111 | 0.083 (0.040) | 0.075 (0.038) | 0.070 (0.037) | 0.068 (0.036) | 0.061 (0.037) | 0.060 (0.037) | Island | S Indian Ocean | Maritime |
| San Nicolas | 532 | 0.11 (0.067) | 0.088 (0.056) | 0.079 (0.048) | 0.072 (0.043) | 0.056 (0.035) | 0.049 (0.030) | Coastal Isl. | S California | Maritime Pollution |
| Tahiti | 344 | 0.098 (0.040) | 0.083 (0.034) | 0.079 (0.032) | 0.074 (0.030) | 0.061 (0.027) | 0.054 (0.026) | Island | S Pacific | Maritime |
| Nauru | 391 | 0.091 (0.041) | 0.077 (0.036) | 0.076 (0.035) | 0.074 (0.035) | 0.068 (0.034) | 0.061 (0.034) | Island | SW Pacific | Maritime |
| Lanai | 542 | 0.099 (0.055) | 0.086 (0.048) | 0.080 (0.042) | 0.074 (0.038) | 0.064 (0.033) | 0.054 (0.028) | Island | Hawaii | Maritime |
| Trinidad Head | 229 | 0.11 (0.076) | 0.096 (0.067) | 0.085 (0.059) | 0.078 (0.054) | 0.061 (0.046) | 0.053 (0.039) | Coast | N California | Maritime |
| Coconut Island | 230 | 0.10 (0.052) | 0.090 (0.055) | 0.085 (0.041) | 0.082 (0.049) | 0.073 (0.041) | 0.061 (0.034) | Island | Hawaii | Maritime |
| Guam | 82 | 0.10 (0.039) | 0.092 (0.036) | 0.093 (0.034) | 0.088 (0.033) | 0.074 (0.031) | 0.068 (0.031) | Island | W Pacific | Maritime |
| Midway Island | 342 | 0.11 (0.057) | 0.097 (0.051) | 0.093 (0.046) | 0.089 (0.045) | 0.078 (0.042) | 0.071 (0.040) | Island | Central Pacific | Maritime |
| Azores | 176 | 0.13 (0.067) | 0.11 (0.060) | 0.10 (0.054) | 0.096 (0.051) | 0.080 (0.047) | 0.069 (0.044) | Island | E Atlantic | Maritime Dust |
| Gustav Dalen Tower | 203 | n/a (n/a) | 0.14 (0.096) | 0.11 (0.081) | 0.098 (0.069) | 0.069 (0.051) | 0.056 (0.031) | Island | N Baltic Sea | Maritime-Cont. |
| Tudor Hill | 94 | 0.16 (0.076) | 0.14 (0.063) | 0.12 (0.055) | 0.11 (0.050) | 0.089 (0.042) | 0.083 (0.038) | Island | W N Atlantic | Maritime Dust |
| Ragged Point | 131 | 0.12 (0.070) | 0.11 (0.067) | 0.11 (0.064) | 0.11 (0.061) | 0.091 (0.057) | 0.088 (0.054) | Island | Barbados | Maritime Dust |
| Bermuda | 340 | 0.17 (0.11) | 0.14 (0.090) | 0.13 (0.080) | 0.11 (0.069) | 0.091 (0.054) | 0.075 (0.044) | Island | W N Atlantic | Maritime Dust |
| Cape San Juan | 154 | 0.13 (0.087) | 0.12 (0.080) | 0.12 (0.075) | 0.11 (0.073) | 0.10 (0.068) | 0.010 (0.067) | Island | Puerto Rico | Maritime Dust |
| Graciosa | 20 | 0.16 (0.049) | 0.15 (0.042) | 0.13 (0.038) | 0.12 (0.036) | 0.11 (0.032) | 0.091 (0.031) | Island | E Atlantic (Azores) | Maritime Dust |
| **La Parguera** | 672 | 0.16 (0.084) | 0.14 (0.075) | 0.13 (0.068) | 0.12 (0.065) | 0.10 (0.058) | 0.086 (0.054) | Coast | Puerto Rico | Maritime Dust |
| **Santa Cruz Tenerife** | 355 | 0.16 (0.092) | 0.14 (0.086) | 0.13 (0.082) | 0.12 (0.079) | 0.11 (0.074) | 0.092 (0.070) | Island | E Atlantic | Maritime Dust |
| Cabo Da Roca | 350 | 0.17 (0.057) | 0.15 (0.10) | 0.11 (0.046) | 0.12 (0.082) | 0.091 (0.065) | 0.075 (0.052) | Coast | Portugal | Continental |
| Gotland | 261 | 0.18 (0.14) | 0.15 (0.12) | 0.13 (0.10) | 0.12 (0.090) | 0.086 (0.067) | 0.068 (0.048) | Island | Baltic | Maritime-Cont. |
| Ersa | 76 | n/a (n/a) | 0.18 (0.080) | n/a (n/a) | 0.13 (0.061) | 0.10 (0.052) | 0.076 (0.046) | Island | Mediterranean | Maritime-Cont. |
| Key Biscayne | 133 | 0.19 (0.12) | 0.16 (0.099) | 0.14 (0.084) | 0.13 (0.073) | 0.010 (0.057) | 0.081 (0.046) | Coast | SE Florida | Maritime Pollution |
| Dry Tortugas | 409 | 0.21 (0.12) | 0.16 (0.10) | 0.14 (0.086) | 0.13 (0.075) | 0.010 (0.059) | 0.074 (0.046) | Island | Caribbean | Maritime Dust |
| **Lampedusa** | 382 | n/a (n/a) | 0.18 (0.11) | n/a (n/a) | 0.14 (0.087) | 0.12 (0.077) | 0.093 (0.068) | Island | Mediterranean | Dust Pollution |
| **IMC Oristano** | 459 | n/a (n/a) | 0.19 (0.10) | n/a (n/a) | 0.15 (0.078) | 0.11 (0.066) | 0.085 (0.055) | Island | Mediterranean | Dust Pollution |
| **Dahkla** | 186 | 0.18 (0.091) | 0.17 (0.090) | 0.16 (0.090) | 0.15 (0.088) | 0.13 (0.083) | 0.11 (0.078) | Coast | W Sahara | Dust |
| Helgoland | 205 | 0.24 (0.16) | 0.20 (0.13) | 0.17 (0.11) | 0.15 (0.098) | 0.12 (0.073) | 0.088 (0.053) | Island | N Sea | Maritime |
| **COVE** | 712 | 0.26 (0.22) | 0.21 (0.18) | 0.18 (0.15) | 0.15 (0.13) | 0.11 (0.097) | 0.071 (0.064) | Coast | Chesapeake | Pollution |
| Sevastopol | 351 | 0.27 (0.14) | 0.22 (0.11) | 0.19 (0.094) | 0.16 (0.082) | 0.12 (0.063) | 0.084 (0.048) | Coast | Black Sea | Maritime Pollution |
| Ascension Island | 522 | 0.22 (0.13) | 0.19 (0.11) | 0.17 (0.097) | 0.16 (0.090) | 0.14 (0.076) | 0.12 (0.063) | Island | S Atlantic | Maritime Smoke |
| **MVCO** | 170 | n/a (n/a) | 0.21 (0.20) | 0.18 (0.17) | 0.16 (0.16) | 0.11 (0.13) | 0.070 (0.086) | Coastal Isl. | Martha's Vineyard | Maritime-Cont. |
| **Forth Crete** | 731 | 0.26 (0.12) | 0.22 (0.099) | 0.19 (0.087) | 0.17 (0.079) | 0.13 (0.067) | 0.10 (0.060) | Island | Mediterranean | Dust Pollution |
| Kaashidhoo | 191 | 0.25 (0.13) | 0.21 (0.11) | 0.18 (0.096) | 0.17 (0.085) | 0.14 (0.070) | 0.11 (0.054) | Island | Indean Ocean | Maritime Pollution |
| **Messina** | 246 | n/a (n/a) | 0.22 (0.13) | n/a (n/a) | 0.17 (0.10) | 0.13 (0.088) | 0.099 (0.076) | Coast | Sicily | Maritime Dust |
| **Villefranche** | 546 | n/a (n/a) | 0.23 (0.15) | n/a (n/a) | 0.17 (0.11) | 0.12 (0.086) | 0.087 (0.062) | Coast | S France | Maritime-Cont. |
| **Capo Verde** | 579 | 0.19 (0.10) | 0.20 (0.10) | 0.17 (0.097) | 0.18 (0.095) | 0.17 (0.089) | 0.15 (0.082) | Island | E Atlantic | Maritime Dust |
| **Inhaca** | 83 | 0.30 (0.20) | 0.24 (0.16) | 0.20 (0.14) | 0.18 (0.12) | 0.15 (0.090) | 0.097 (0.070) | Coastal Isl. | Mozambique | Cont-Smoke |
| MALE | 79 | 0.28 (0.15) | 0.24 (0.13) | 0.21 (0.11) | 0.19 (0.096) | 0.16 (0.073) | 0.11 (0.055) | Island | N Indian Ocean | Maritime Pollution |
| **Shirahama** | 567 | 0.30 (0.16) | 0.25 (0.14) | 0.21 (0.12) | 0.19 (0.11) | 0.14 (0.085) | 0.11 (0.062) | Coast | E Japan | Maritime Pollution |
| **Venise** | 1388 | 0.35 (0.21) | 0.27 (0.18) | 0.23 (0.15) | 0.19 (0.13) | 0.14 (0.096) | 0.091 (0.062) | Coast | Italy | Maritime-Cont. |
| **IMS METU-Erdemli** | 918 | 0.33 (0.18) | 0.27 (0.15) | 0.23 (0.13) | 0.20 (0.12) | 0.15 (0.090) | 0.11 (0.067) | Coast | SW Turkey | Maritime-Cont. |
| **Arica** | 604 | 0.34 (0.14) | 0.29 (0.12) | 0.26 (0.11) | 0.23 (0.095) | 0.18 (0.075) | 0.14 (0.051) | Coast | Chile | Pollution |
| MCO Hanimadhoo | 120 | 0.35 (0.15) | 0.30 (0.13) | 0.27 (0.11) | 0.24 (0.098) | 0.19 (0.077) | 0.14 (0.061) | Island | N Indian Ocean | Maritime Pollution |
| **Dakar** | 392 | 0.27 (0.12) | 0.27 (0.11) | 0.24 (0.10) | 0.24 (0.10) | 0.22 (0.094) | 0.19 (0.087) | Coast | Senegal | Dust |
| Hong Kong Hok Tsui | 30 | 0.38 (0.14) | 0.32 (0.13) | 0.28 (0.11) | 0.25 (0.094) | 0.19 (0.073) | 0.13 (0.047) | Coast | China | Pollution Dust |
| Gosan-SNU | 126 | 0.40 (0.18) | 0.33 (0.17) | 0.29 (0.13) | 0.26 (0.14) | 0.20 (0.10) | 0.16 (0.077) | Coastal Isl. | S Korea | Pollution Dust |

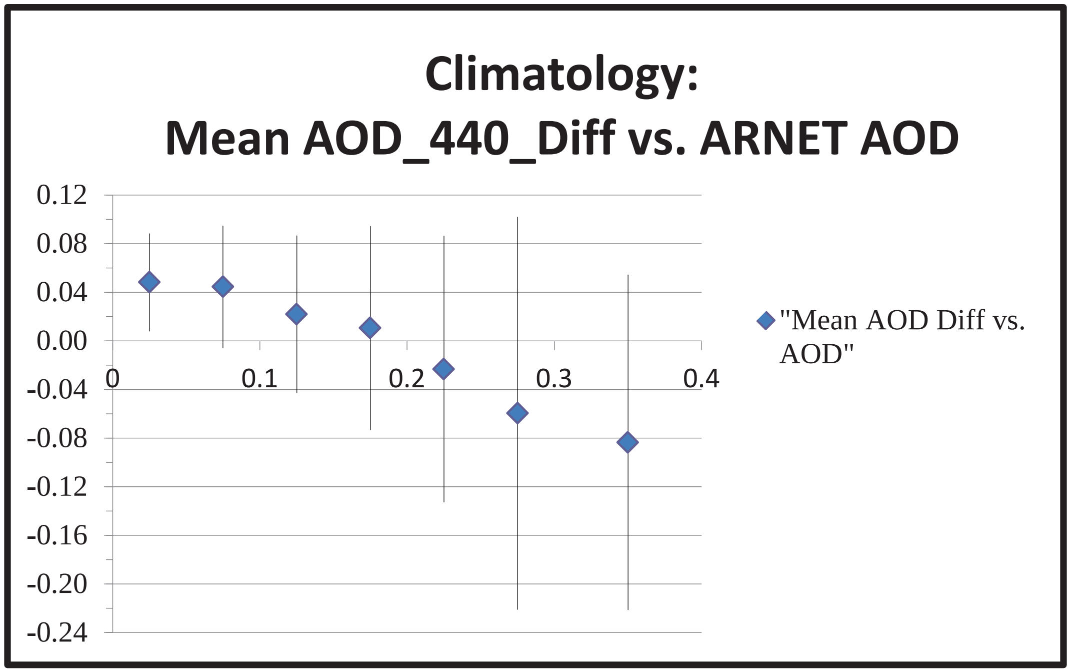
**Sites having specific events with mid-visible AOD > 0.35 identified in the current dataset

*Kahn, Sayer, Ahmad, Franz, in preparation*

# 16,154 *AERONET - SeaWiFS* **Coincidences**
## [49 AERONET Sites]

**AOD_440:**

[Calculated using ***SeaWiFS*** Algorithm] – [***AERONET***-Measured]




Seven AOD bins of equal AOD width (except the largest AOD bin)
"Error" bars represent 1 standard deviation

*Kahn, Sayer, Ahmad, Franz, in preparation*

# ***Chlorophyll* *absorbs*** *incoming radiation*

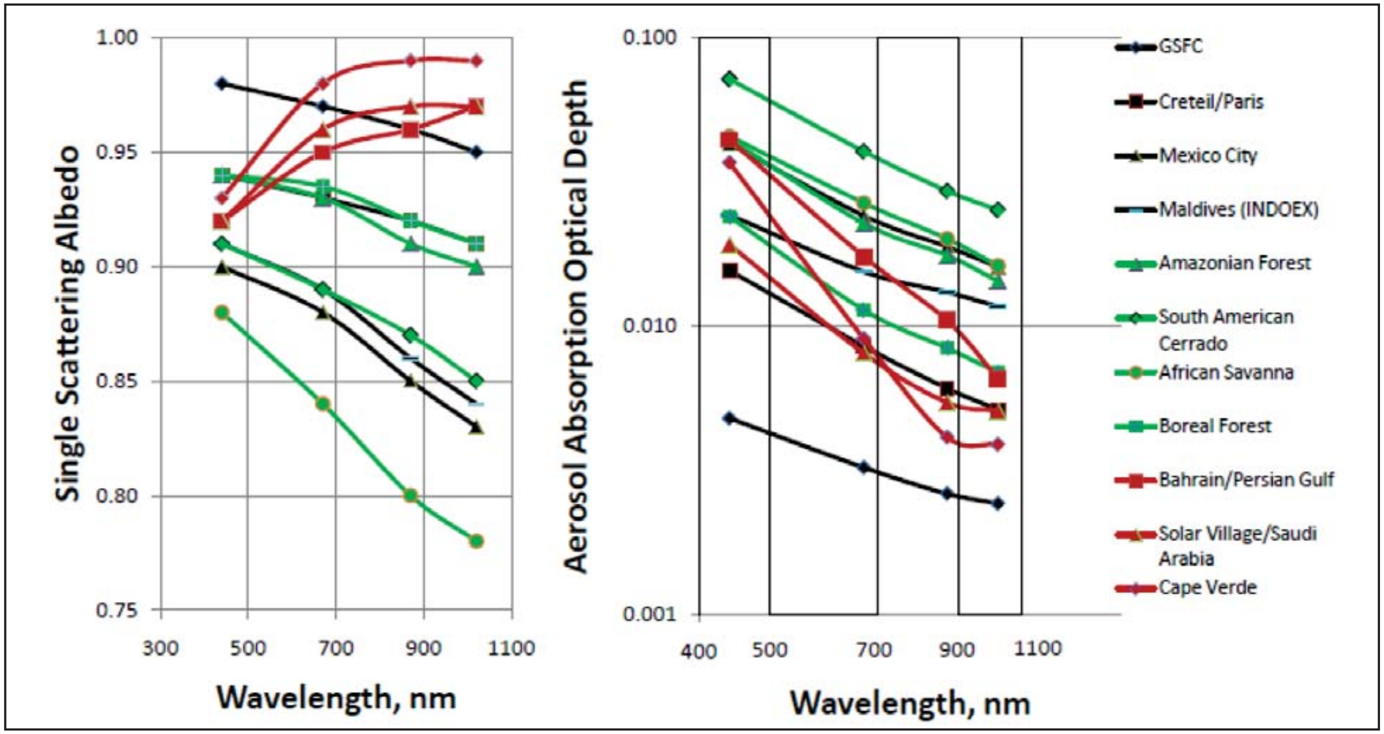
- ***Absorbing aerosols decrease*** the TOA reflectance, and if uncorrected, will produce an ***underestimate*** of surface reflectance, and chlorophyll concentration could be ***overestimated***

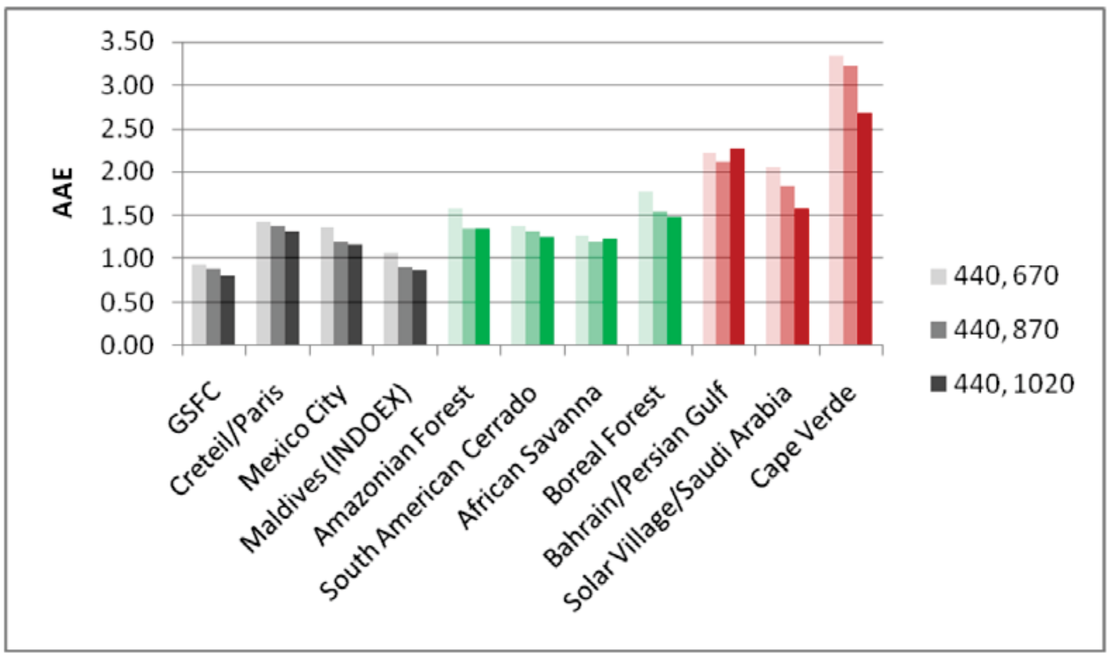
- ***Scattering aerosols increase*** the TOA reflectance, and if uncorrected, will produce an ***overestimate*** of surface reflectance, and chlorophyll concentration could be ***underestimated***

Uncorrected ***absorbing aerosols*** can produce negative surface reflectance, a clearly unphysical result

*Kahn, Sayer, Ahmad, Franz, in preparation*

# Single-Scattering Albedos and Absorption ANGs

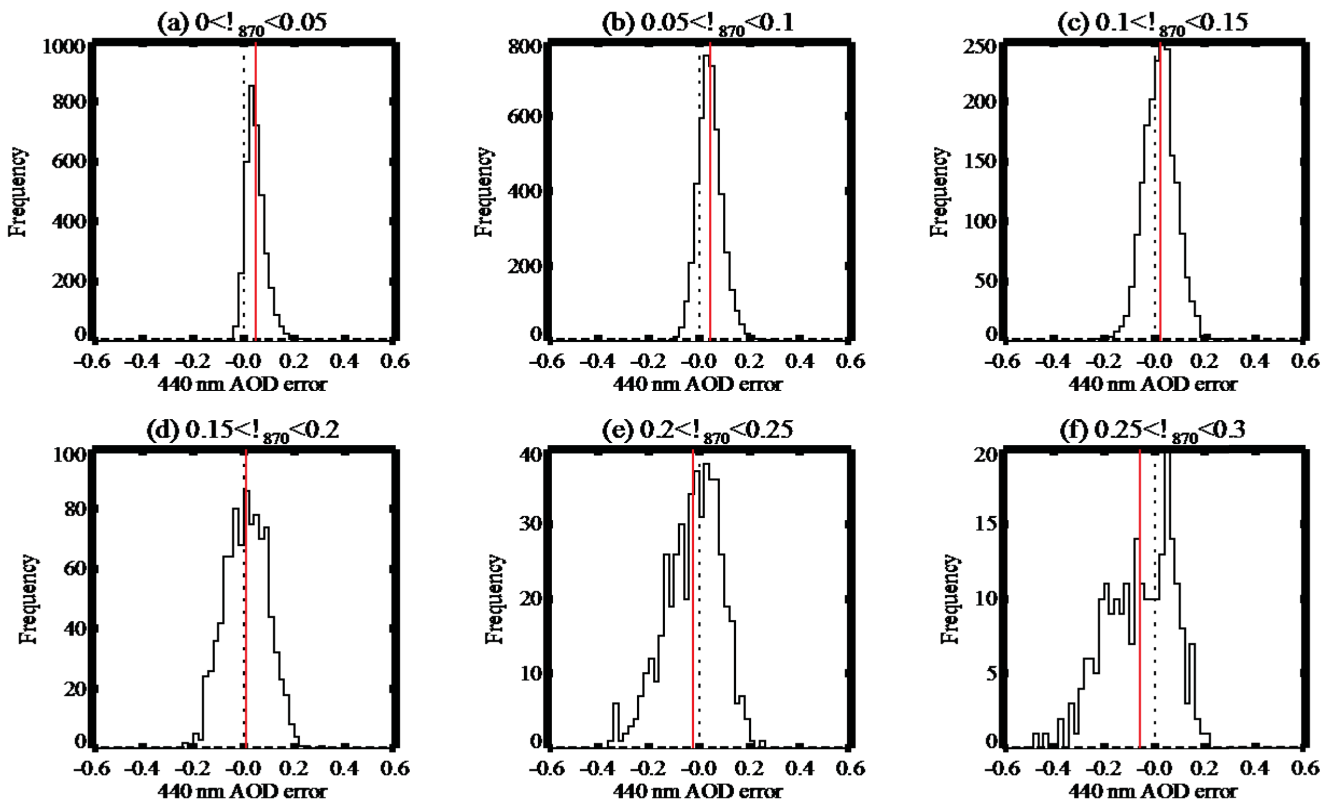


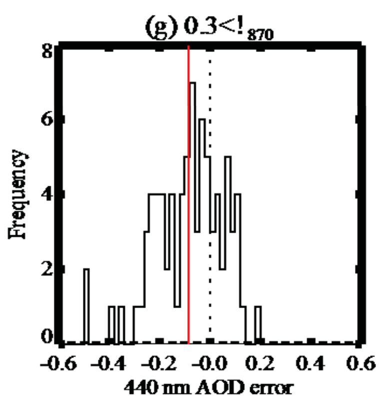




**Dust**
**Smoke**
**Pollution**

*Russell et al., ACP 2010*

# 49 AERONET Sites; 16,154 *SeaWiFS* Coincidences




**AOD_440 errors**

[SeaWiFS – ARNT] AOD

- 7 AOD bins
- Increase with AOD
- *Exceed*: +0.2, -0.4
- Bi-modal for AOD>~0.2

***Bi-modal*** histograms for AOD >~ 0.2

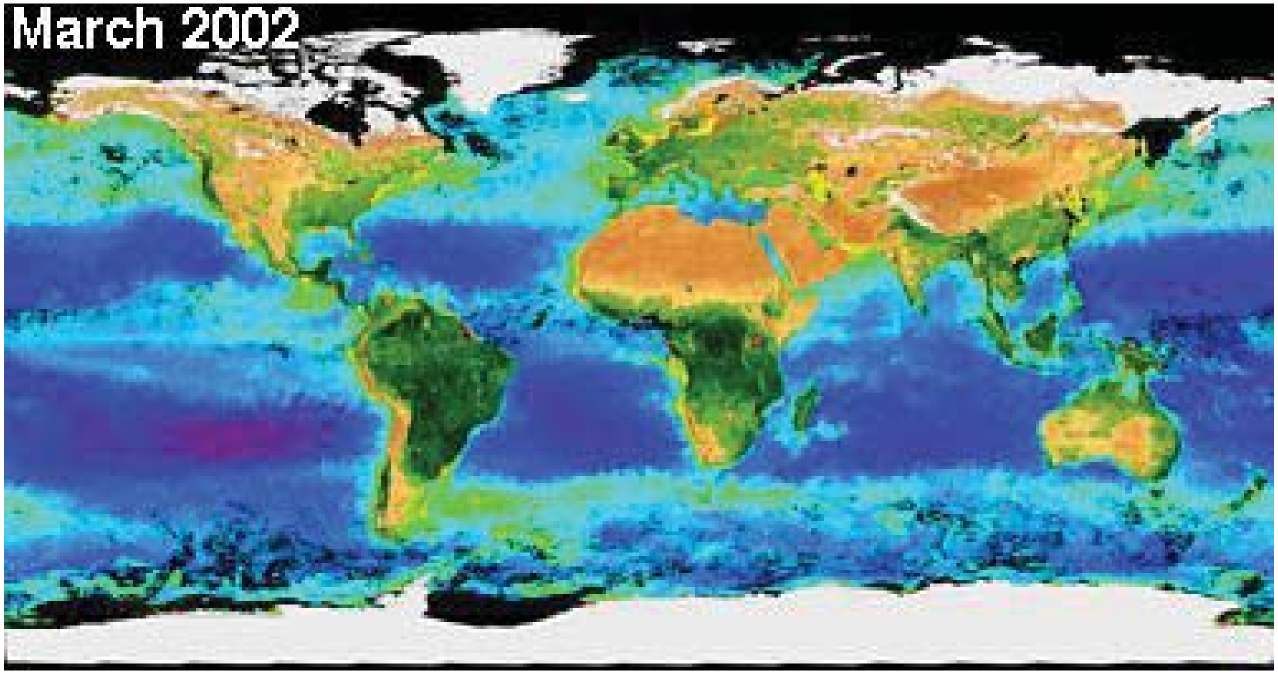
- ***Low-AOD anomaly*** mostly ***dusty*** (*more* ***scattering***) cases
- ***High-AOD anomaly*** likely ***smoke***, ***pollution*** (*more* ***absorbing***)

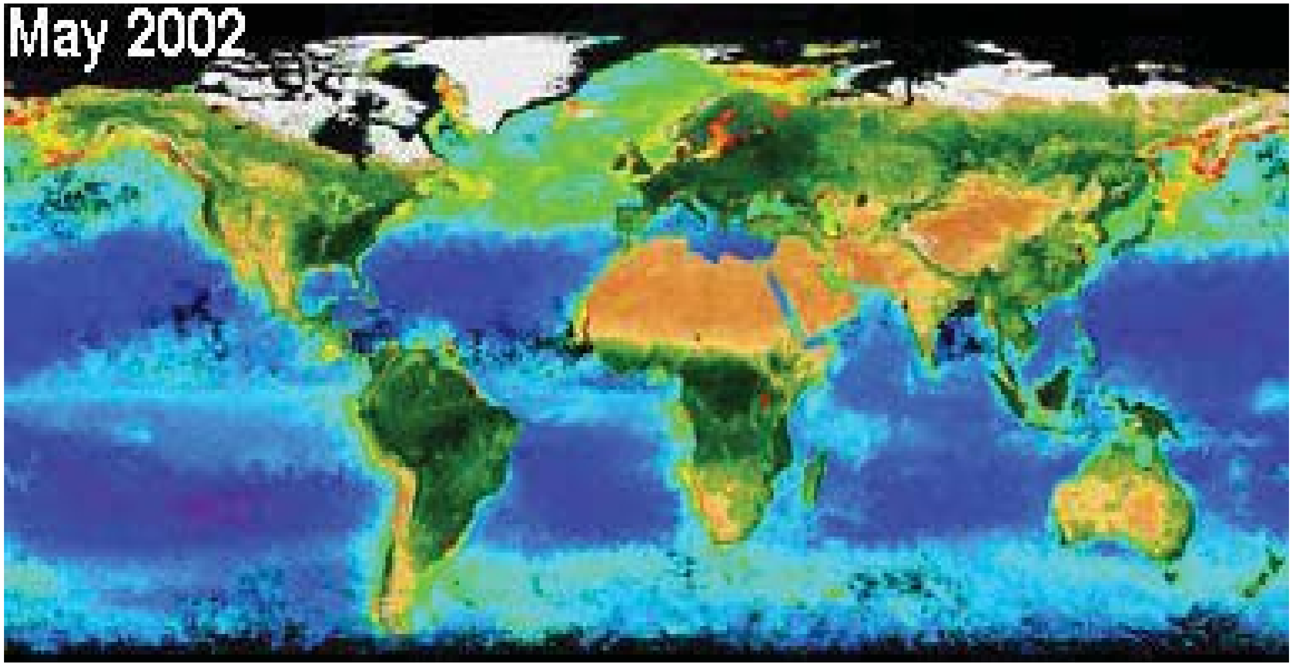
→ ***Aerosol Type Matters***, even qualitatively

See also: *Li et al*. 2003; *Schollaert et al*. 2003; *Ransibranmanakul & Stump*, 2006; *Ahmad et al*. 2010

*Kahn, Sayer, Ahmad, Franz, in preparation*

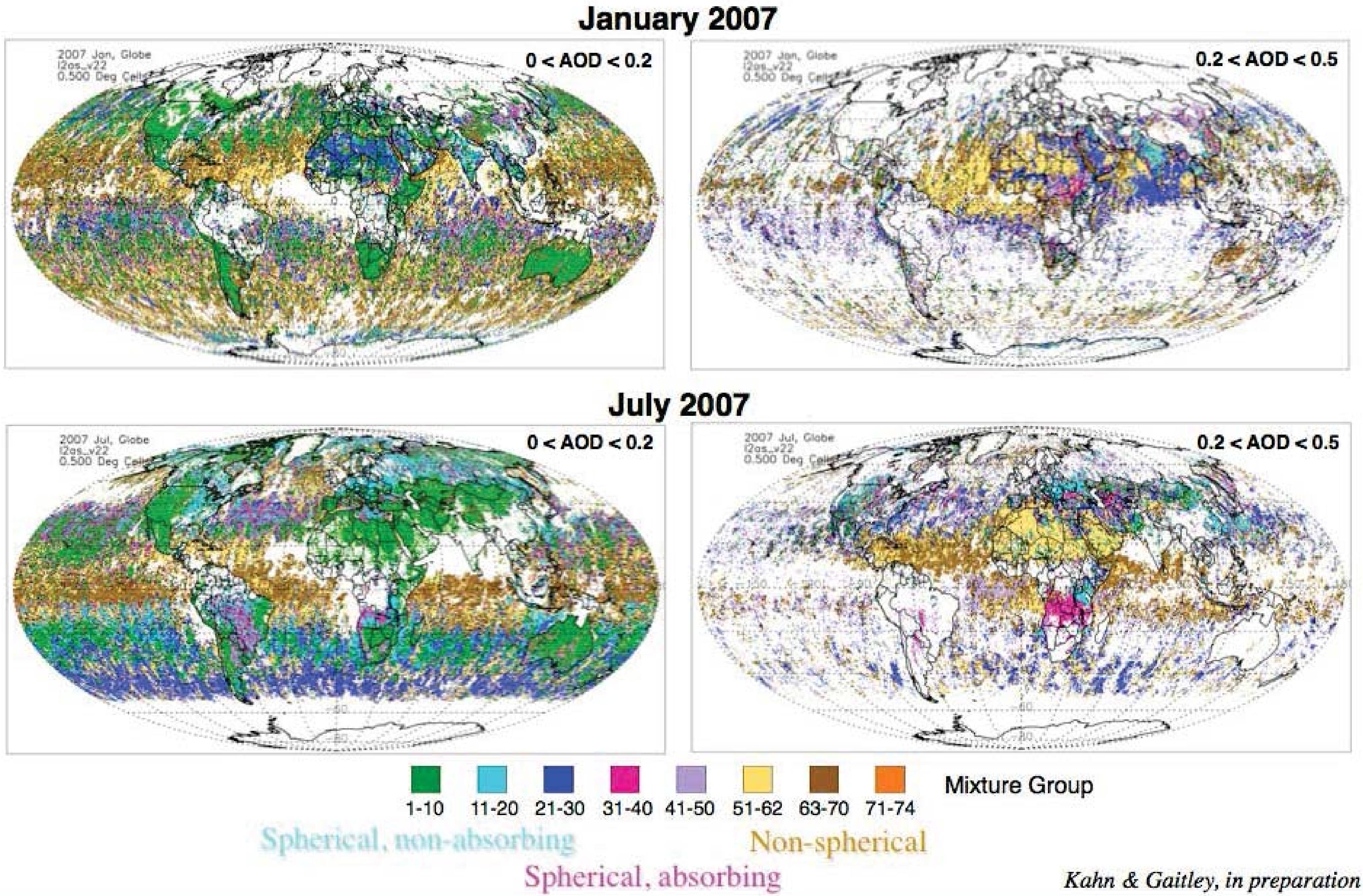
# SeaWiFS-Retrieved Chlorophyll-a Concentrations




*OceanColor.gsfc.nasa.gov*

# Global Distribution of MISR Most Frequently Retrieved Mixture Group




*Kahn & Gaitley, in preparation*

# Atmospheric Correction Requirements

Ocean Color ***parameter sensitivity*** requirements →

Ocean ***surface reflectivity*** sensitivity requirements (λ) →

TOA ***reflectivity*** sensitivity requirements (λ, AOD, type) →

Aerosol ***Type, AOD*** sensitivity requirements

Going to the uv ***increases*** the sensitivity to atmospheric signal

**Will the standard procedure be adequate for the next-generation Ocean Color objectives?**